

T07D07 – HL 2012 Equilibrium Exam MS

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|-----|---|-----|-------------|------|------|------------------------------------|----------|------|-----|------|------|-----|--------|-----|-----|-----|-----|-------|-------------------|
| 1. | A | (4) | IB Chem HL1 | | | Free Response Section (Paper 02) | | | | | | | | | | | | Total | |
| 2. | B | (4) | Level: | MC | FR | Grade | Possible | 3 | 4 | 5 | 6 | 7 | Cutoff | 56 | | | | | |
| 3. | B | (4) | Above +6 | 0% | 0% | 2 | 0 | 50% | 0.5 | 40% | 4.8 | 30% | 7.8 | 20% | 2.6 | 10% | 0.4 | 16 | BELOW STANDARD |
| 4. | B | (5) | Above +5 | 10% | 10% | 3 | 1 | 80% | 0.8 | 50% | 6 | 40% | 10.4 | 30% | 3.9 | 20% | 0.8 | 22 | |
| 5. | D | (5) | Above +4 | 20% | 20% | 4 | 12 | 90% | 0.9 | 80% | 9.6 | 50% | 13 | 40% | 5.2 | 30% | 1.2 | 30 | |
| 6. | A | (6) | Above +3 | 35% | 30% | 5 | 26 | 95% | 1 | 90% | 10.8 | 80% | 20.8 | 50% | 6.5 | 40% | 1.6 | 41 | |
| 7. | B | (5) | Above +2 | 45% | 40% | 6 | 13 | 100% | 1 | 95% | 11.4 | 90% | 23.4 | 80% | 10 | 50% | 2 | 48 | ABOVE |
| 8. | D | (7) | Above +1 | 55% | 50% | 7 | 4 | 100% | 1 | 100% | 12 | 95% | 24.7 | 90% | 12 | 80% | 3.2 | 53 | Total 10 |
| 9. | D | (7) | Level | 80% | 80% | Multiple Choice Section (Paper 01) | | | | | | | | | | | | | |
| 10. | D | (6) | Below -1 | 90% | 90% | Grade | Possible | 3 | 4 | 5 | 6 | 7 | Cutoff | | | | | | |
| | | | Below -2 | 95% | 95% | 2 | 0 | 55% | 0 | 45% | 1.35 | 35% | 1.05 | 20% | 0.4 | 10% | 0.2 | 3 | |
| | | | Below -3 | 100% | 100% | 3 | 0 | 80% | 0 | 55% | 1.65 | 45% | 1.35 | 35% | 0.7 | 20% | 0.4 | 4 | |
| | | | Below -4 | 100% | 100% | 4 | 3 | 90% | 0 | 80% | 2.4 | 55% | 1.65 | 45% | 0.9 | 35% | 0.7 | 6 | |
| | | | Below -5 | 100% | 100% | 5 | 3 | 95% | 0 | 90% | 2.7 | 80% | 2.4 | 55% | 1.1 | 45% | 0.9 | 7 | |
| | | | Below -6 | 100% | 100% | 6 | 2 | 100% | 0 | 95% | 2.85 | 90% | 2.7 | 80% | 1.6 | 55% | 1.1 | 8 | BELOW STANDARD |
| | | | Below -7 | 100% | 100% | 7 | 2 | 100% | 0 | 100% | 3 | 95% | 2.85 | 90% | 1.8 | 80% | 1.6 | 9 | ABOVE |

11. (a) (4x1)A; (4x1)E; 2

If 3 choices shown [1 max], if 4 choices shown [0].

- (b) (i) (5x1)after 15s (product) = 0.37 (mol dm⁻³);
 (6x1)rate = $\frac{0.37}{15}$ = 0.025;
 2 sig figs
 (4x1)mol dm⁻³s⁻¹/Ms⁻¹/M/sec; 3
 (ii) (5x1)at equilibrium/rates of forward and reverse reactions are equal/ $\Delta G = 0$; 1

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12. No ECF throughout this question.

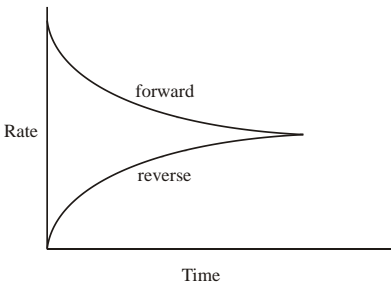
- (a) (4x1) $K_c = \frac{[N_2O_4]}{[NO_2]^2}$ 1
 (b) (5x1) K_c decreases;
 (6x1)forward reaction is exothermic/ ΔH is negative/equilibrium moves to left/OWTTE; 2
 (c) (7x1) (mixture will get) darker/darker than expected;
 (5x1)equilibrium position moves to the left/towards reactants as there is an increase in the number of moles of gas from right to left; 2
 (d) (6x1) (equilibrium mixture contains) less (than 2 moles NO₂);
 (5x1)given values make $\frac{[N_2O_4]}{[NO_2]^2} = \frac{1}{2}$ i.e. too much NO₂/OWTTE; 2

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13. (a) removed
 (b) (4x1) $K_c = \frac{[H_2][I_2]}{[HI]^2}$; 1
 Ignore state symbols.

- (c) (i) experiment 1 (7x1) [HI] = 0.06 (mol dm⁻³);
 (5x1) [I₂] = 0.01 (mol dm⁻³);
 (5x1) $K_c = \frac{(0.01)^2}{(0.06)^2} = 2.7E - 2$
 ECF from above values.
 experiment 2 (7x1) [H₂] = 0.04 (mol dm⁻³);
 (7x1) [I₂] = 0.04 (mol dm⁻³);
 (5x1) $K_c = \frac{(0.04)^2}{(0.08)^2} = 0.25$ 6
 ECF from above values.
 (ii) (5x1)experiment 2 (at higher temperature);
 (6x1)higher K_c value/equilibrium shifted to right; 2

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14. (i) $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 4\text{H}_2(\text{g}) + \text{CO}_2(\text{g})$;
States not required. (5x1) balanced equation and (3x1) equilibrium sign.
(4x1) $K_c = \frac{[\text{H}_2]^4 [\text{CO}_2]}{[\text{CH}_4][\text{H}_2\text{O}]^2}$;
 ECF
(5x1) units: $\text{mol}^2 \text{dm}^{-6} / \text{mol}^2 \text{L}^{-2} / \text{mol}^2 \text{l}^{-2}$; do not accept: M^2 4
 ECF
- (ii) **(5x1)** (endothermic reaction) increase in temperature (favors the forward reaction);
(6x1) absorbs (some of) the heat supplied/OWTTE;
Award no marks for saying: "because of Le Chatelier's principle".
(6x1) low pressure (will allow system to occupy more volume);
(5x1) $V_{\text{product}} > V_{\text{reactant}}$ /reaction proceeds to greater number of gaseous moles /molecules/more moles of gases on right/OWTTE;
 ECF from (i) 4
- (iii) **(5x1)** at high pressure concentration increases/reaction rate faster;
(4x1) more frequent collisions; 2
15. (a)
- 
- (5x1)** two curves – one labeled "forward" starting up high up y-axis and one labeled "reverse" starting from zero;
(6x1) curves merge and become horizontal;
 No penalty for failing to label axes.
forward reaction:
(5x1) highest concentration, thus rate high to begin with;
(6x1) as reaction proceeds, concentrations decrease, so does rate;
reverse reaction:
(6x1) zero rate initially/at $t = 0$ (since no products present);
(5x1) rate increases as concentration of products increases;
(6x1) equilibrium established when rate of forward reaction = rate of reverse reaction; 7
- (b) **(5x1)** (reaction is) endothermic;
(6x1) K_c increases with (increasing) temperature;
(6x1) forward reaction favored/heat used up/OWTTE; 3
16. (a) **(5x1)** $K/K_c = [\text{SO}_3]^2 / [\text{SO}_2]^2 [\text{O}_2]$;
Accept correct K_p expression. 1
- (b) (i) **(3x1)** vanadium(V) oxide/(di)vanadium pentaoxide/ V_2O_5 ;
Allow just vanadium oxide but not correct formula. 1
- (ii) **(5x1)** catalyst does not affect the value of K_c ;
(5x1) forward and reverse rates increase equally/by the same factor;
(4x1) catalyst increases the rate of the reaction;
(5x1) (by providing an alternative path for the reaction with) lower activation energy; 4
- (c) **(5x1)** more energetic collisions/more molecules have energy greater than activation energy;
(4x1) more frequent collisions; 2
Do not accept more collisions without reference to time.
- (d) (i) **(4x1)** shifts equilibrium position to the products/right;
(5x1) to the side with fewer gas molecules or moles/lower volume of gas; 2
- (ii) **(4x1)** shifts equilibrium position to the products/right;
(5x1) to compensate for loss of SO_3 /produce more SO_3 ; 2
- (iii) **(4x1)** no effect;
(5x1) forward and backward rates increased equally/by the same factor; 2

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